HURT

HETEROGENEOUS URBAN RSTA TEAM

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Agenda

0800 - 0810:	Welcome, Introductions
0810 - 0815:	Agenda
0815 - 0830:	Opening Comments
0830 - 1000:	HURT Program Briefing
1000 - 1045:	Break
1045 - 1100:	Contracting
1100 - 1200:	Q & A

NOTE: Use of recording devices is prohibited.

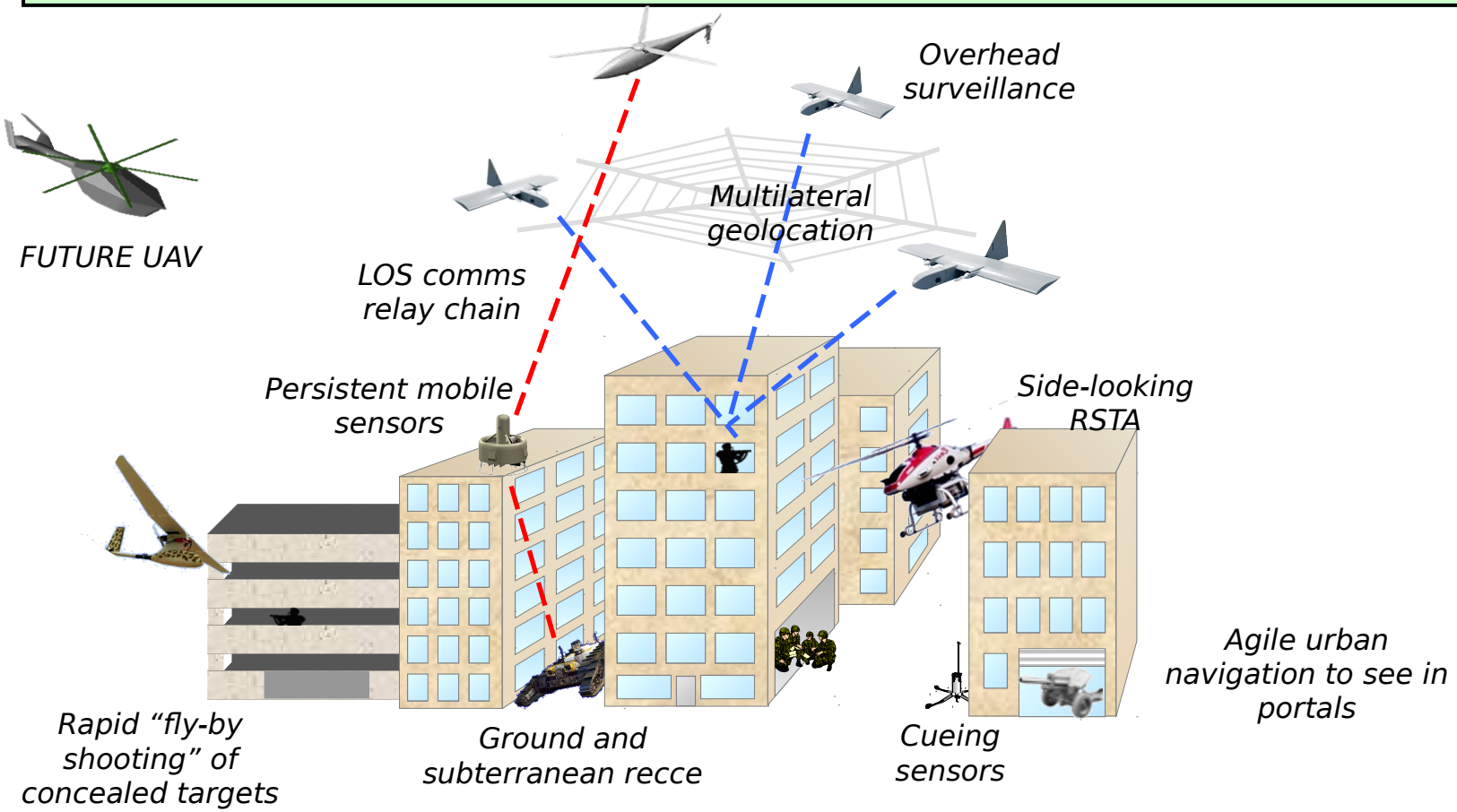
HURT: Overview

***HURT** is a multi-vehicle controller that coordinates and collaboratively plans urban RSTA missions for autonomous vehicles. It implements **augmented autonomy** for teams of arbitrary vehicle platforms.*

- **What it Does**
  - HURT gives the warfighter the ability to ask directly for images unobtainable with high-altitude or fixed sensors.
- **The Benefit Achieved**
  - HURT can produce order-of-magnitude improvement in urban campaign effectiveness through pervasive RSTA coverage
- **The Technology**
  - HURT will develop innovative collaborative control technology to achieve collective autonomy that is superior to unit or sub-team autonomy
- **The Program**
  - Will result in demonstration of RSTA service-requests for warfighters in MOUT.

HURT Provides On-Demand Collaborative RSTA for Obscured Targets

Urban RSTA requires horizontal viewpoints and rapid reaction to cues and perceived threats



The HURT control layer can make existing vehicles behave like a distributed robotic sensor

HURT Provides a High-Level Multi-Vehicle Tasking Interface

HURT makes it possible to issue high-level commands to the team of vehicles.

- "Monitor <designated area>"
- "View <Coordinate> from <perspective>"
- "Search <feature> for <pattern>"
- "Map area defined by <bounds>"
- "Establish comms net among <nodes>"
- "Deliver <payload> to <coordinate>"
- "Fly as decoy along <route>"

High-level tasking

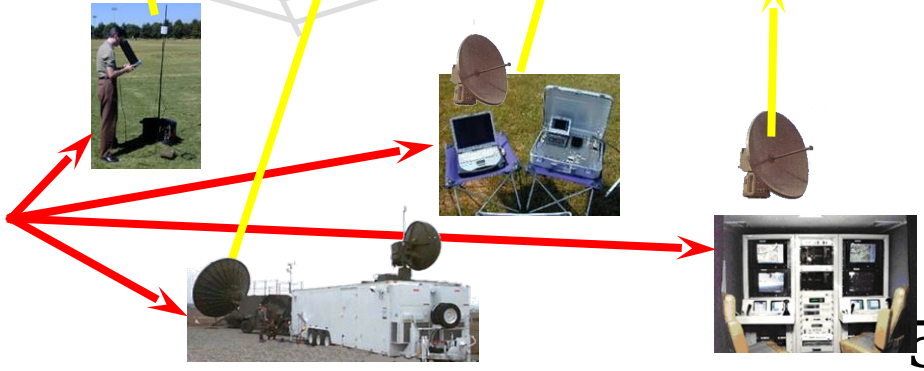
HURT provides a common, shared command interface to capabilities of the RSTA assets

Heterogeneous, networked unmanned systems

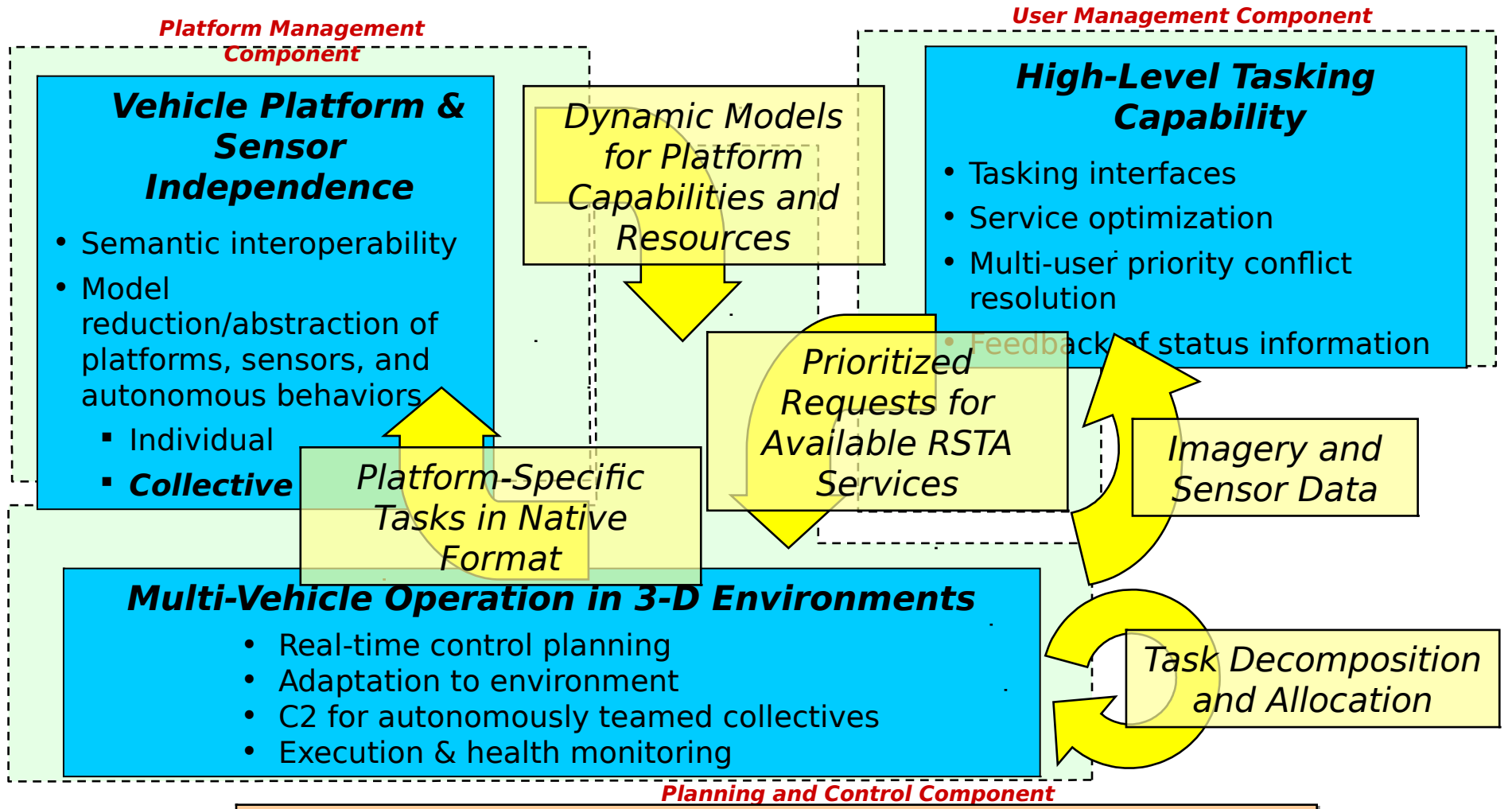
HURT user(s)

High-level RSTA service command

HURT control center exploits existing UAV datacomms



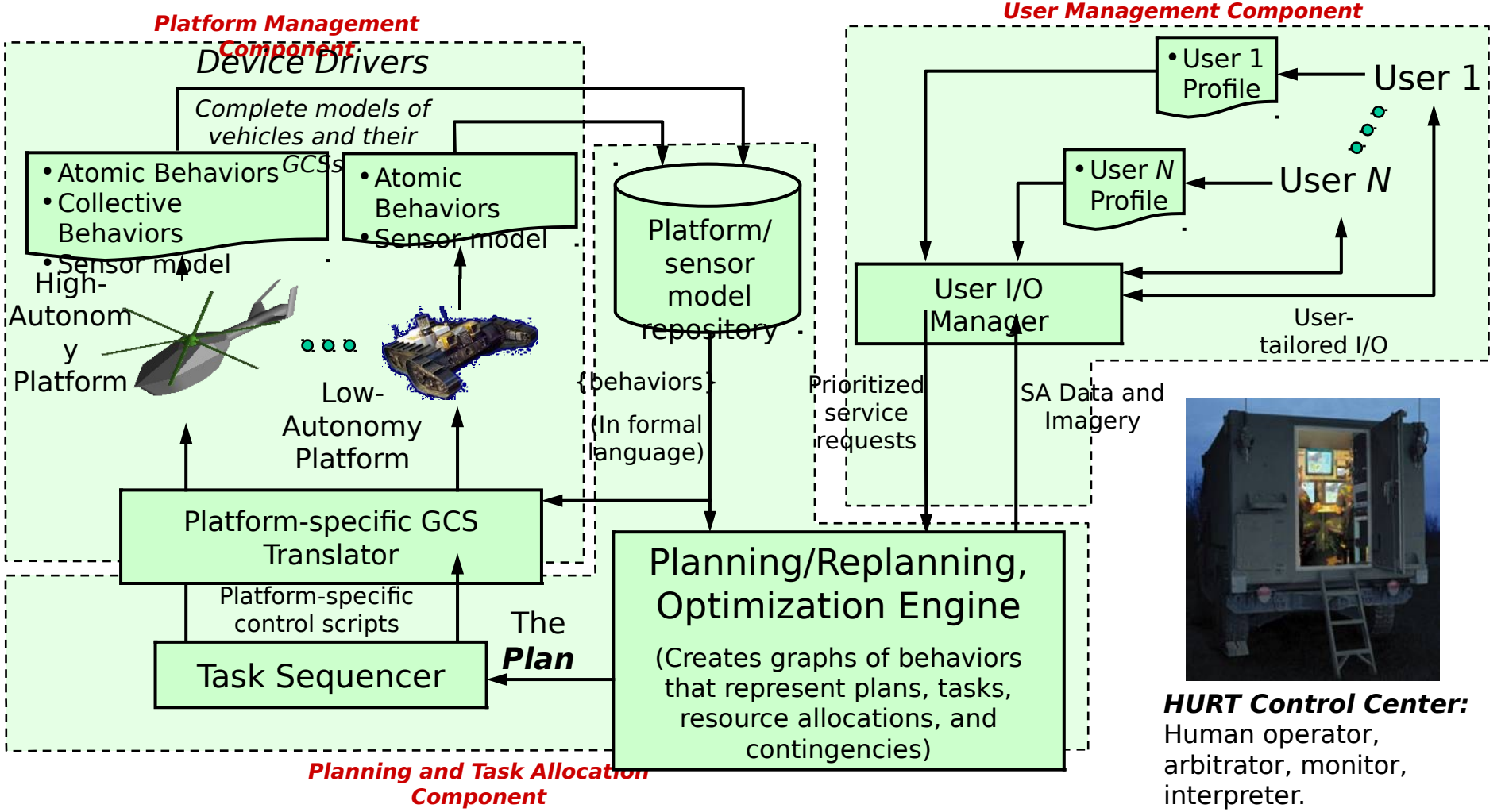
Three Innovative Technology Components



NOT PART OF HURT:

- Exploitation algorithms (though exploitation proxy model **will** be required)
- Human-in-the-loop data processing
- Maintenance or population of common operating picture

A Highly Autonomous System from Arbitrary Platforms

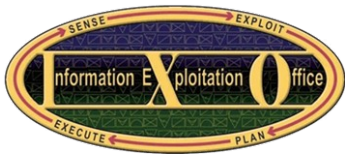


HURT Control Center: Human operator, arbitrator, monitor, interpreter.

HURT's centralized autonomy allows platforms to come & go; their collective autonomy remains the same

New Hard Problems to Solve

What we can already do (but maybe not fast enough):	Problems HURT must solve:
– *Syntactical* interoperability (i.e., static device drivers)	– *Semantic* interoperability (i.e., with autonomous teams)
– *Single-vehicle* maneuver autonomy	– *Collective autonomy* characterization for command and control
– Multi-user quality-of-service control	– Critic (commander)-assisted multi-asset control
– Hierarchical planning in *quasi-static* environments	– Hierarchical planning in *real-time dynamic* (5 sec.) environment
– Resource allocation in *fully observable environment*	– Resource allocation in fully *dynamic & uncertain* environment
– Control with prioritized inputs	– Mission-based prioritization in MIMO service allocation



User Management

People in the HURT Chain

HURT System

Users

HURT Command and Control Center

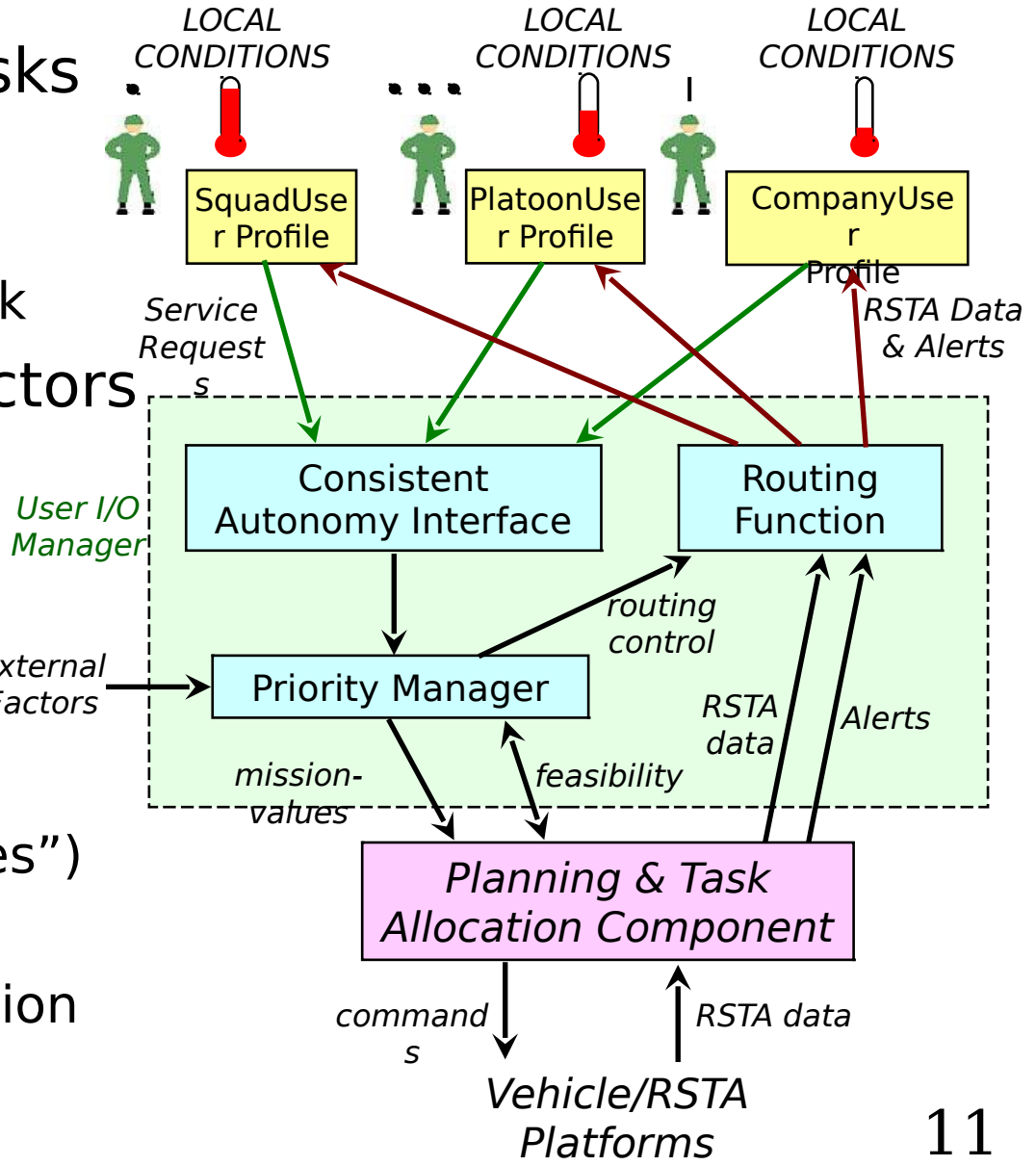
Operator(s)
Commander

Platforms

Ground
Controllers

User Management
Coordinates Real-Time Services to Warfighters

- User Management Tasks
  - Priority management
  - Information return
  - Status display/feedback
- Conflicting Priority Factors
  - Echelon/rank
  - Threat level
  - Time criticality
  - ROE
- New Technologies
  - User modeling (“profiles”)
  - Value-focused queuing
  - Intent-based prioritization



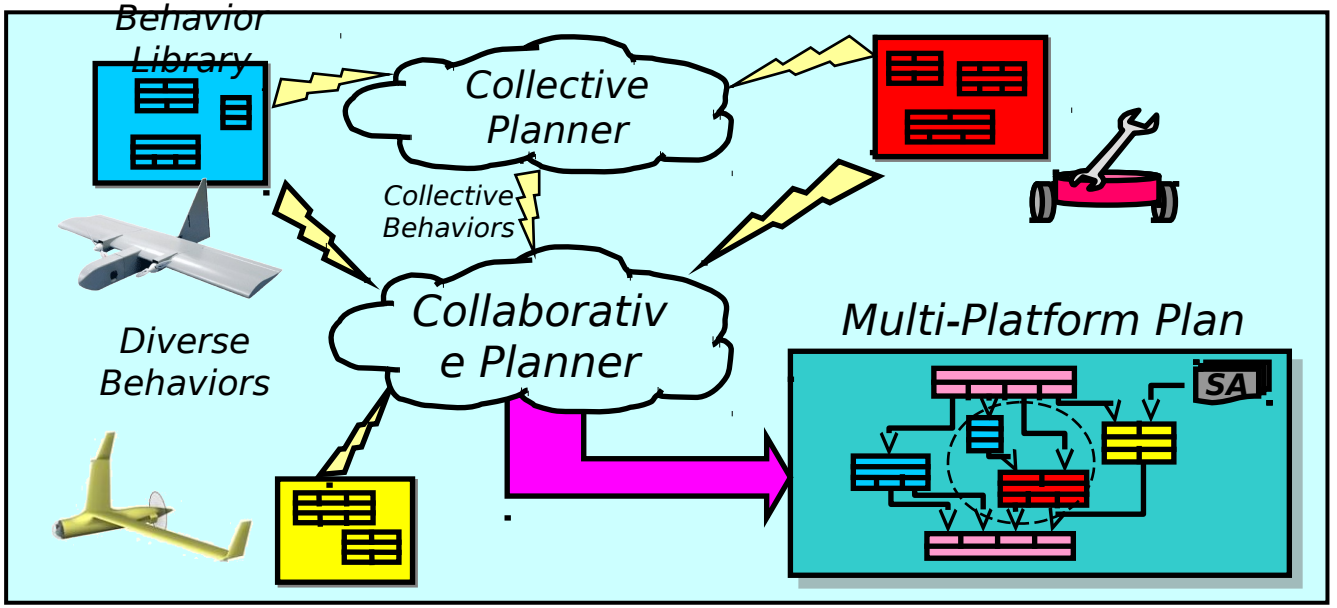
User Priority Resolution

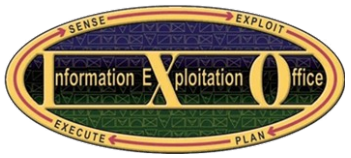
- Fragmented, isolated users issuing “calls for RSTA”
- Compare to AFATDS (“calls for fires” management)
  - Commander issues guidance in form of
    - Target priority weights
    - Designation of high-payoff targets (HPTs)
    - Filters for minimum targeting criteria
      - Maximum target location error (TLE)
      - Maximum report age
    - Consideration of special targeted areas of interest (TAIs)
  - Weighted average gives target attack list; then commander’s decision
- HURT-unique features
  - Artillery shells can’t multi-task; UAVs can
  - Want *automatic* mission value function, not commander’s tool
    - But still need to capture commander’s guidance

Platform (and Sensor) Management

Platform Modeling Based on Capabilities, not Implementations

- Model and plan elements are based on autonomous capabilities, not physical attributes
  - Preserves platform-independence, growth path, and technology insertion
  - Facilitates uniformity in interfaces and training
  - Easily adapts to platform faults
- Maintains an explicit formal model of multiple-vehicle capabilities
  - Plans can be based on mixed-vehicle capabilities
  - Plans include allocation of payloads/sensors: single and multiple



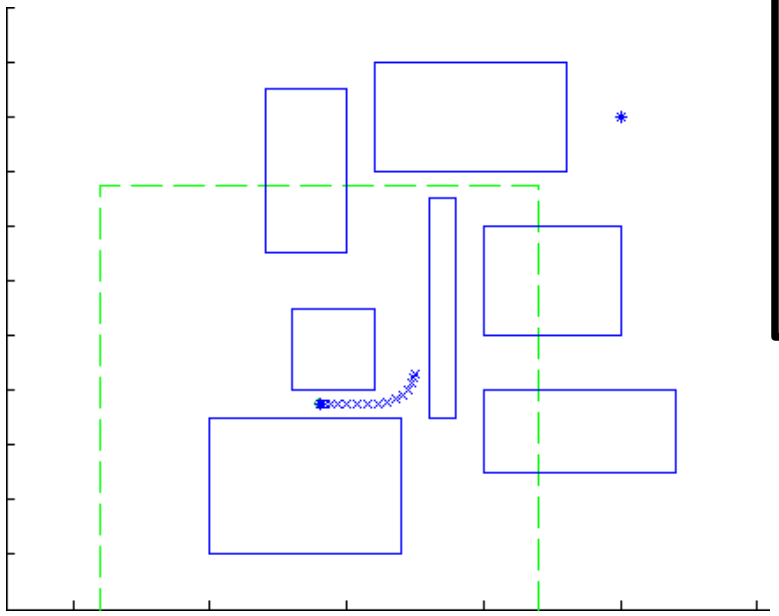


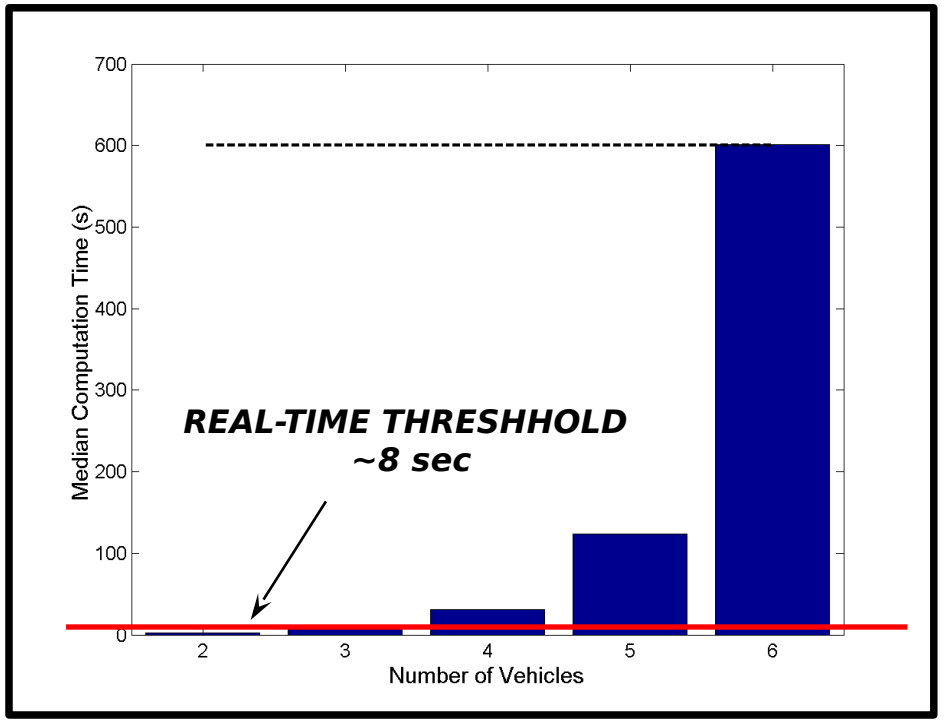
Planning and Control

Even "Simple" Multi-Vehicle Coordination is Hard to Plan…

"Show me a picture of Locations <X> ASAP"
→ HURT system must dispatch vehicles to coordinates <X>

- Plan trajectories with consideration of vehicle dynamics
- Maintain a safe "escape" maneuver
- Cooperatively manage the airspace

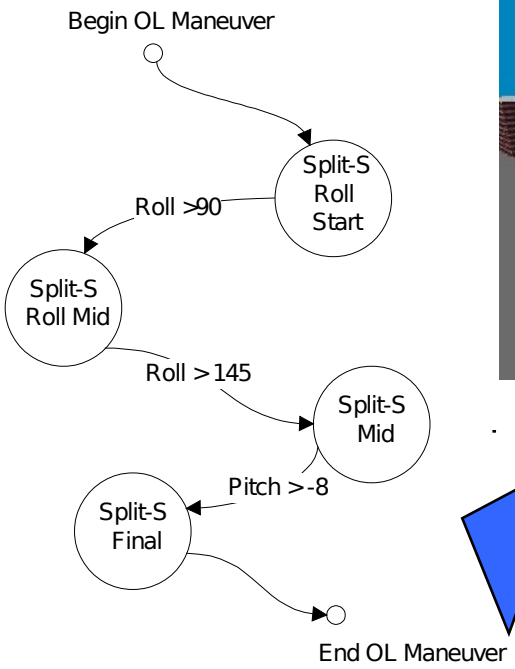




… and this problem still lacks the heterogeneity aspect !!

Taking Control to Higher Levels for Autonomous Systems

- Autonomous vehicles in complex domains can control themselves over a finite library of maneuvers
- Coordinating them at higher levels requires planners that operate over the space of lower-level controlled behaviors



Problem is *EXPSPACE-complete,* and scales according to

$$\sum_{k=0}^{m} B_{n-k} \binom{m}{k}$$

For *n* vehicles and *m* known tasks ($\approx (5\text{x}10^{14})^m$ for 20 vehicles)

*A **Hard** Planning Problem:*

Given a vehicle model and its autonomous control primitives, find a graph to accomplish a task such as time-optimal navigation from p_1 to p_2, in *real-time* and with *stability guarantees*.

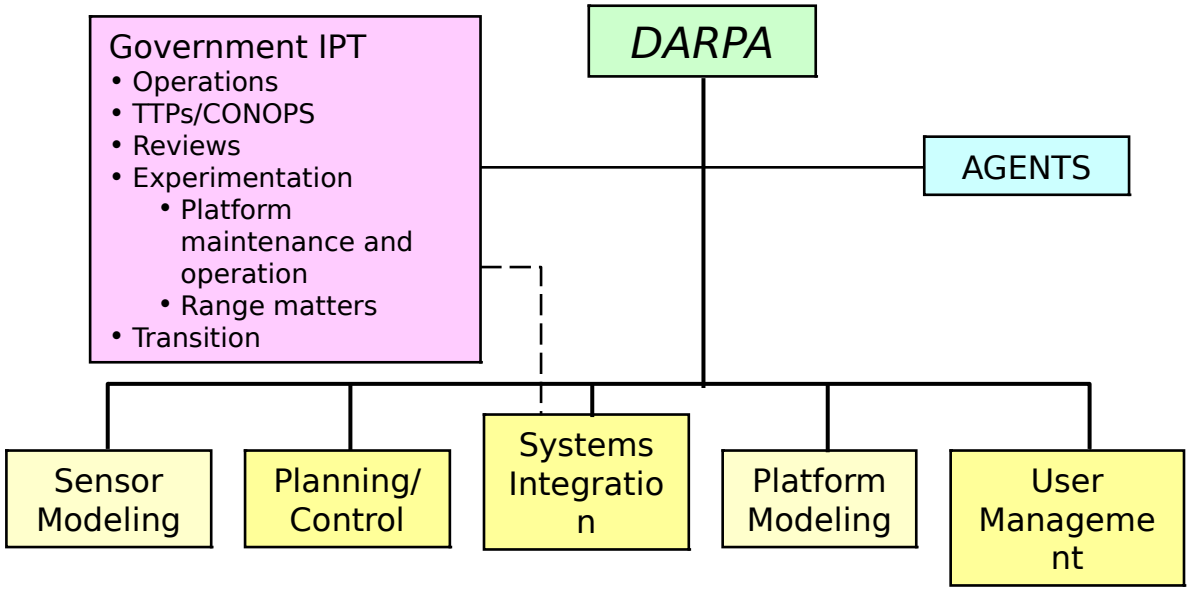
*A **Harder** Planning Problem:*

Given a collection of vehicle models and multi-vehicle **collective** behaviors, task the vehicles in such a way as to optimize the services provided to the users,

The HURT Program

HURT: The Program

- Contractor teams for the big three problems:
  - Platform & sensor management (maybe two teams)
  - User management
  - Planning, control, & task allocation
- *PLUS*: Systems integrator
- Bidders can propose multiple areas
- Three phases with integrated demonstrations at MOUT site:



Two-Dimensional Assessment Strategy

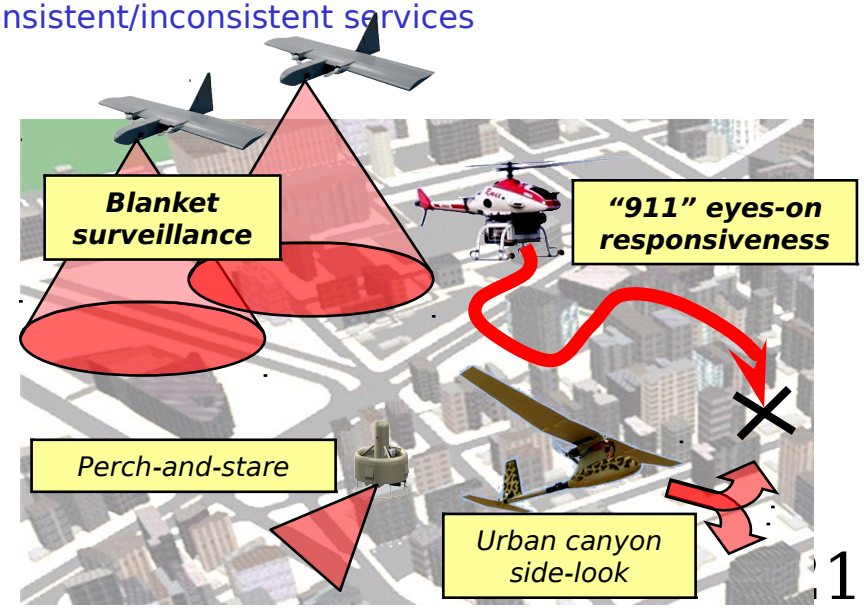
1. Produce entirely new capabilities at each phase
   - Innovative features at each demonstration

	14 months	*16 months*	*18 months*
	Phase 1	Phase 2	Phase 3
Theme & Purpose	***Remote Autonomy*** *HURT must demonstrate coordinated augmented autonomy*	***Collective Autonomy*** *HURT must manage collective tasks in a dynamic environment*	***Tactical Autonomy*** *HURT-controlled teams must effectively serve warfighters in tactical scenarios*
Demo with exit criteria	• ≥ 3 air vehicles plus stationary sensors • .5km X .5km continuous street area coverage of MOUT site with portal revisit rate ≤ 5 min. • Vehicles 100% autonomous (except for failure recovery) • Single user	• ≥ 6 mixed vehicles in pool • Autonomous group behaviors: – coordinated search – maintain moving urban AOR with targets moving 50mph (human-assisted designation) • Autonomous track handoff • Two users	• ≥ 8 mixed vehicles in pool • Mixed control capability: multiple users with overlapping requirements – LOS connectivity – Viewpoint maintenance • Fault tolerance: 10% comms dropouts and 50% platform degradation

2. Fixed Test Scenario with parametric metrics
   - Each new capability should improve comparable measure of effectiveness

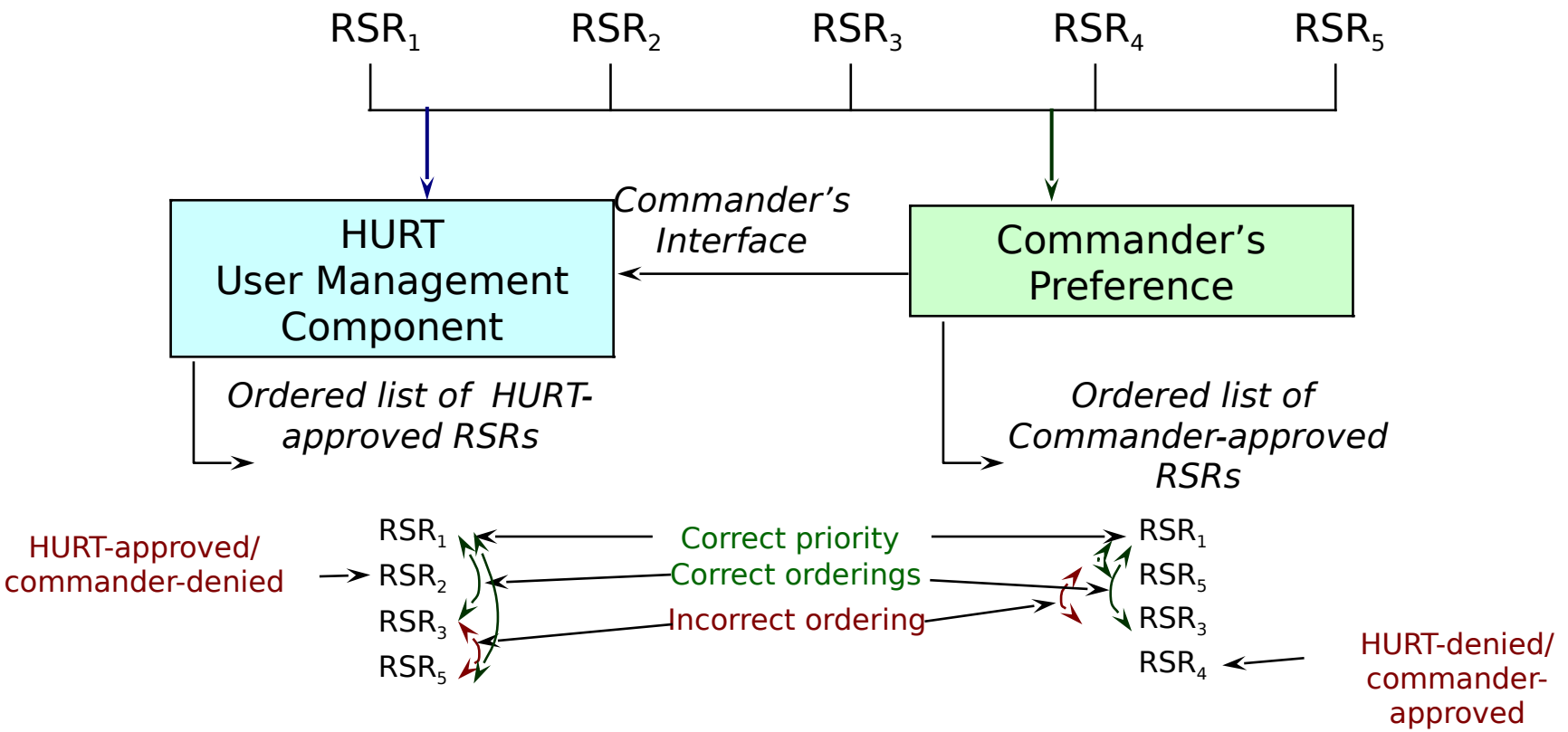
Operational Vignette Provides Fixed Test Scenario

- Fixed Scenario: Two simultaneous collective tasks:
  - Wide-area surveillance (e.g., curfew maintenance)
  - Rapid responsiveness
- Three major requirements
  - *Full Sensor Coverage* over the entire AO
    - MEASUREMENT: # personnel needed to control platforms that cover the whole AO
  - *Eyes-On Latency* to cueing events; requires view of any point in the AO
    - MEASUREMENT: time to reach any requested 6 DOF point following cue
  - *New Platform Insertion Delay* to demonstrate robustness and flexibility
    - MEASUREMENT: time from delivery of new platform to its full integration in team
  - *Prioritization* of user requests consistent with commander's guidance
    - MEASUREMENT: confusion matrix showing consistent/inconsistent services
- Comparison to existing capabilities
  - Manned Force (MAGTF) with existing equipment, TTPs
  - Conventional UAVs (e.g., Predator)



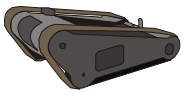
User Management Confusion Matrix

- User Requests: RSR (RSTA Service Requests)
  - Specific, well-formed commands to the HURT system



Potential Platforms Have Diverse Capabilities and Controls










Platform	Payload	Range	Endurance	Sensors	Control
Raven MOUT UAV	0.4 lb	10 km	75 min	One IR or combo of down-and side-looking daylight camera.	GPS autopilot.
PUMA “urbanized” Pointer UAV	2 lb	8 km	120 min	Daylight camera housing; side-look capable.	GPS autopilot.
Matilda ground robot	125 lb	1.5 km	N/A	Modular payload	Teleoperated only.
Dragon Eye UAV	1 lb	4.0 km	60 min	Downward-looking EO/IR.	GPS autopilot.
Maverick UAV	300 lb	200 km	7 hours	Modular payload	SEC asset, variable autonomy
Silver Fox UAV	4 lb	2400 km	24 hours	Downward-looking EO/IR.	GPS autopilot.
OAV (29” version)	20 lb	50 km	90 min	EO/IR downward and slant-angle.	GPS + ?
Yamaha RMAX Autonomous	60 lb	200 km	90 min	Modular payload, inc. new stabilized sensor ball	GPS autopilot.
Predator	450 lb	5500 km	40 hr	EO/IR sensor ball plus SAR, ESM, comms, SIGINT/ELINT	Piloted or GPS waypoints
Fire Scout	200 lb	320 km	6 hrs	EO/IR sensor ball plus SAR, ESM, comms, SIGINT/ELINT	TCS

Sample HURT Tasks

- Platform Modeling
  - Vehicle modeling
  - Collective modeling
  - Constraint modeling
  - Command translators
  - Sensor selection, modeling, and integration
  - Exploitation proxies (to support data-driven applications)
- User management
  - User interfaces
  - Request status feedback
  - Commander's guidance-based prioritization
  - Quality of service optimization
- Planning, Control, Task Allocation, and Optimization
  - Planning and control algorithms
  - Airspace and constraint management
  - Fault Management
  - Plan monitoring, execution, and repair
- Systems Integrator
  - Computing architecture, infrastructure and software
  - Unmanned system interfaces
  - Platform management
  - Operator and Commander interfaces
  - Communications management
  - Verification, validation, flight & range safety
  - Test and evaluation, Measures of Performance, Measures of Effectiveness

Evaluation Factors

- Relevance to HURT mission objectives
- Technical innovation and depth
- Consistency with HURT program concepts
- Personnel and corporate capabilities and experience
- Cost realism and value of proposed work the Government

Closing Comments

Why HURT Now?

- Urgency of urban operations problem
  - The threat of urban warfare
  - Need to take action on lessons learned before the next conflict
- Proliferation of platforms and user demands
  - Dragon Eye, Silver Fox, Raven, OAVs
  - Polarization of UAV capabilities (UCAR vs. RAVEN)
  - Standardization of ground stations (stable ICDs)
- Emerging CONOPs and future needs
  - Documents from all services feature multi-UAV scenarios
- Why not the services?
  - Services are all platform-centric
- Big Picture Innovation
  - HURT manages collaborative system intelligence off-board, facilitating platform-independence, growth, training, upgradeability, and interoperability.

HURT technology will NEVER become obsolete

Useful URLs

- Briefing to Industry pre-solicitation announcement
  - http://www.tfims.darpa.mil/bti
- DARPA/IXO Solicitation sites
  - http://www.darpa.mil/baa/#ixo
  - http://www.darpa.mil/ixo/solicitations.asp (not up yet)
    - (will have link to FAQ)
- Proposal registration site
  - http://www.tfims.darpa.mil/baa
- Questions?
  - Baa04-05@darpa.mil

Solicitation Schedule

- FedBizOpps pre-solicitation 24 October 2003
- Briefing to Industry 20 November 2003
- BAA release (target) 12 December 2003
- Proposals due 13 February 2004
- Selections announced 1 June 2004
- Kickoff meeting 15 June 2004